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Atmospheric Measurement Techniques Discussions

Interactive comment on "Improved scattering radiative transfer for frozen hydrometeors at microwave frequencies" *by* A. J. Geer and F. Baordo

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Referee comments are in italics

Section 3.1: The tropical version of Field et al. (2007) was used in this study, and I presume this methodology was applied globally to generate, eg..=, Figures 2 8 that show results from a broader latitudinal range. Are there potential deleterious effects for doing so, or do the authors surmise that the relative difference between the various snow scattering models will accordingly remain the same if the midlatitude Field et al. (2007) relationships are applied outside of the tropics? The Field et al. parameteri-

zation is appealing due to its simple temperature-dependence, so I am encouraged to see improved results using DDA with the Field et al. methodology versus the Mie and Marshall Palmer combination.

It is true that the tropical version of the Field et al. (2007, F07) size distribution was used globally in this study and we did not consider the midlatitude version at all. It is not clear how the relative difference between snow scattering models will behave with the midlatitude version and we have not tested this. We used one size distribution globally in part to reduce complexity and in part because the current design of RTTOV-SCATT makes it very hard to switch between size distributions according to the latitude, for example.

Sensitivity tests with the sector snowflake (the recommended particle shape) show that changing from the tropical to the midlatitude version of the F07 size distribution reduces brightness temperatures. In other words it enhances the amount of scattering. Reductions in simulated brightness temperatures in convection and frontal systems are of order 1 K in 37-50 GHz channels and of order 5 K at 90 GHz and above. The sector snowflake already generates slightly too much scattering in the midlatitudes; using the midlatitude version of F07 would make this worse. To go further we would need to specifically look at midlatitude conditions and reconsider the best choice of size distribution and particle shape. Hopefully this can be left for future work.

Section 3.1: Regarding integrating the bulk scattering properties over the size distribution, did the authors methodologically extrapolate scattering properties from the DDA databases if, for instance, the derived size distribution contained particles of sizes larger than the original DDA simulations? Or were scattering properties truncated at a dynamically maximum particle size for each of the respective snow models? This effect would probably only matter for certain DDA models like plates and columns.

In our calculations there is no extrapolation. At the upper end the size distribution is terminated at the maximum particle size from the Liu database, for example $10^5\,\mu m$ in

the case of the rosettes and the sector snowflake. At the lower end we do not allow the F07 size distribution to generate ice particles smaller than $100\,\mu m$ as the distribution is not constrained by observational data below this.

For some combinations of size distribution and particle shape there can be a significant amount of truncation of the size distribution. However, this tends to occur only for very small water contents (i.e. situations with very little radiative impact) and very large liquid water contents (i.e. situations that are extremely infrequent). Hence, we do not think there will be much real impact from the truncation. However, to prevent any loss of particle mass, we renormalise the size distribution so that the numerically integrated liquid water content across the truncated size range (e.g. the numerical equivalent of Eq. 7 in the paper) equals the water content for which we are computing optical properties.

We will document this better in our revised manuscript.

Section 5.1: In the first paragraph, the 3- and 6-bullet rosettes, plus dendrite and sector snowflakes, are presented as the more realistic snow models, yet they individually fall on either side of the ideal fit. Would a better strategy be to take a small ensemble average of these particles' scattering properties to see if this is doctrine works better on a global scale? This ensemble strategy, however, might mask some of the deficiencies outlined on P. 18 related to individual DDA models.

This point overlaps with our answer to referee 2's question, which asked whether the search was constrained by the available particle models. This is certainly true and the ensemble approach is a possible solution. We would like to add this point to the conclusion of the paper. Another idea for the future is to try ensembles in which the particle shape changes as a function of size, for example using pristine ice shapes for small sizes and aggregates for larger sizes.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 1749, 2014.